Graphics for Three-Term Contingencies

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A source of confusion in the general readership regarding the relationship of operant to S-R psychology is traced to the use of graphics in the behavioral literature. A case is made for supplementing traditional linear notation systems with triangular graphics to illustrate three-term contingencies. Constructing discriminative stimuli in this fashion makes the distinction between operant and S-R formulations more conspicuous and reveals more comprehensive relationships for an extended radical behaviorism.

In 1931/1972, Skinner defined the reflex as "the observed correlation of two events, a stimulus and a response," and maintained that "description of behavior is adequately embraced by the principle of the reflex" (pp. 456-457). The source for this two-part formula was traced to Descartes' "mechanism of the stimulus" (p. 432), which had evidently been modeled on the fountain figures constructed by engineers for the royal fountains of France. These figures were designed to move by means of water power released by triggering mechanisms that could be hidden under the tiles around the fountain. When these tiles were stepped upon, the statues of the fountain moved. Descartes' accounts of a physical world controlled by contiguous, two-part, linear, cause and effect connections can be seen in parallel to the action of constructed mechanisms; and Skinner saw "the stimulus is an essential part of a mechanistic theory of behavior" (p. 434). Skinner went on to emphasize the importance of a linear sequence of antecedent events in producing behavior:

The full description of an event is taken to include a description of its functional relationships with antecedent events. In the description of behavior we are interested in the relationships within a regressive series of events extending from the behavior itself to those energy changes at the periphery which we designate as stimuli. We stop here in the regression only because further steps are beyond the field of behavior. The two end events, the behavior and the stimulus, have, moreover, a particular importance, because they alone are directly observable in an in-

tact organism, and because they limit the series. With the relationship of these two end terms, the description of behavior is chiefly concerned. (p. 449)

In positing a fundamental two-term, stimulus-response explanation for behavior, Skinner at that time was firmly in the tradition of John Watson (1913) and the explanation of an S-R behavioral psychology.

Since then, Skinner has repeatedly rejected the adequacy of S-R explanations as stated in that early paper (which was part of his doctoral thesis) and as stated by S-R psychologists (Skinner, 1938, 1953, 1966, 1969, 1974). In this change of position, Skinner's early emphasis on antecedent stimuli for controlling a response within a *two-term* formulation shifted decidedly toward an emphasis on consequences within a *three-term* formulation of antecedent condition, behavior, and consequence. This shift contributed to initiating another behavioral tradition in operant psychology, which has been considered in more or less opposition to the earlier S-R tradition.

Unfortunately, the differences in Skinner's earlier and later positions, like the difference between S-R and operant psychology, have not been clearly communicated to many readers of the behavioral literature (Day, 1969; Hineline, 1980; Ringen, 1976). Far too many people, who we wish would know better, fail to distinguish Skinner and operant psychology from the S-R formulation. Even W. K. Estes (1954), who had coauthored with Skinner, has applied the S-R label to him. The functional analysis of behavior in terms of consequences within three-term contingencies is repeatedly confused with interpretations of behavior that focus on antecedent

connections in two-part forumulations. This has led to some rather bizarre statements of interpretation. For example, Flood and Lapp (1981) say, "Skinner (1966) in his definition of operant conditioning, stated that a stimulus elicits a response which reinforces a stimulus" (p. 53). Skinner, of course, made no such statement. The distinguishing feature of the operant is an emitted, not an elicited, response; nor do responses reinforce stimuli in the basic operant formulation. One way of resolving this problem is to introduce conspicuous stimuli into the behavioral literature for making this discrimination. Doing this through the language of the text, however, has not been sufficient to date; and graphic displays for illustrating this difference have been curiously deficient, as I trust the following will demonstrate.

Skinner himself has never developed conspicuous graphics for three-term contingencies that communicate easily to a general readership. He seems to have been reluctant to go beyond paralinguistic, linear notations for this formulation. (The highly successful graphing procedures for charting behavior which Skinner helped to develop are another matter.) In a restricted sense, linear notations might not even be considered as a graphic display, but for our purposes we will consider them as a limiting kind of one-dimensional structure in graphic representation.

Figure 1 shows the evolution of Skinner's graphics for distinguishing operant from respondent conditioning in his early writings (1935/1972, 1937/1972, 1938). The operant, which is a functional class concept, is perhaps Skinner's most significant conceptual contribution to psychology. It is for this reason that Skinner has repeatedly maintained that he is not an S-R psychologist. As can be seen, however, Skinner's graphical notation for the operant relies on S and R notation. On the basis of Skinner's graphics, it would be difficult to blame the casual reader for

	Respondent	Operant
1935	TYPE II $S'_0 \longleftarrow \quad \longrightarrow R'_0$ $S'_1 \longrightarrow \quad \searrow R'_1$	TYPE I $S_0 \longrightarrow R_0 \longrightarrow S_1 \longrightarrow R_1$
1937	TYPE S $S_0' \longrightarrow r$ $\downarrow \quad \searrow$ $S_1' \longrightarrow R_1'$	TYPE R $s \longrightarrow R_0 \longrightarrow S_1 \longrightarrow (R_1)$
1938	"The case involving a correlation with a stimulus (Type S) may be represented as follows: $S^0 \searrow \quad \bullet \quad (R^0)$ $S^1 \quad \bullet \quad \searrow R^1$ where S^0 is a stimulus which elicits the irrelevant response R^0 but does not (in the typical case) elicit R^1 prior to conditioning, and where S^1 is a reinforcing stimulus eliciting R^1." (p. 62)	"The second type of conditioning, in which the reinforcing stimulus is correlated with a response, may be represented as follows: $s \bullet R^0 \longrightarrow S^1 \bullet R^1$ where $s \bullet R^0$ is some part of the unconditioned operant behavior of the organism and S^1 is again a reinforcing stimulus." (pp. 65-66)

Figure 1. The early evolution of Skinner's notational graphics for distinguishing the operant.

describing Skinner as an S-R psychologist, or perhaps as s-R psychologist with a small *s*. Since these early formulations, it has become common to represent the fundamental three-term formulation for a functional analysis of behavior as S^D - R - S^r (discriminative stimulus, response, reinforcing stimulus) or simply S-R-S in less specific notation. In later writings for a more general public, Skinner (1969) prefers to rely on the language of the text rather than a separate graph: "An adequate formulation of the interaction between an organism and its environment must always specify three things: (1) the occasion upon which a response occurs, (2) the response itself, and (3) the reinforcing consequences. The interrelationships among them are the 'contingencies of reinforcement' " (p. 7). This statement is a clear expression of a three-component, three-way relationship.

The S-R-S display, however, does not show Skinner's three-component, three-way relationship very well. One problem is that the *S* symbol for antecedent stimulus is in the same prominent first position as it is in the S-R formulation when it is used to indicate an elicited rather than an emitted response. In fact, the S-R-S formulation is consistent with the construction of one and a half S-R chains (S-R plus S). This may have value in illustrating the historical origins in which Skinner distinguished operant (s-R) from respondent (S-R) behavior, but the distinction between these two constructions of discriminative stimuli is a bit subtle for those lacking the background of the readers for whom Skinner originally wrote. Another problem lies in the repeated use of the same two *S* and *R* symbols for both formulations. This notation is more appropriate for two-component, dyadic formulations and for illustrating a chain of dyadic components. Graphics constructed in this way are appropriate for linear cause and effect chains and were well suited for S-R psychologists like Hull. They are less suited for fundamentally three-component formulations.

While linear formulations have substantial utility and convenience and we substantial utility and convenience and we would not want to dismiss them, they do have their limitations. Ordinary language is fundamentally patterned in this way, and we can often express non-linear concepts in a linear representation without confusion. However, given a choice among graphics, there are better ways than a straight linear sequence for indicating the interrelationships between three components. S-R-S and the frequently used A-B-C (for *A*ntecedent, *B*ehavior, *C*onsequence) formulations have only two lines to indicate relationships between symbols. There is no line to indicate the relationship between the symbols for antecedent stimulus and consequence. An evolving interaction between the organism and its environment, indicating all the major interrelationships, is not that well represented by linear constructions for three-component, three-way formulations.

The value of using appropriate graphics has been well established in charting behavior, in the use of Venn diagrams (circles) for clarifying logical relationships, and in scientific discourse in general. Even when the information contained in a graph can be easily presented in other ways, say in a table or within the rest of the text, a particular graphic display makes certain relationships more conspicuous than they would be in another form. The following demonstrates how certain modifications in the use of graphics for three-term contingencies could clarify fundamental conceptions.

Many of the problems referred to in the representation of a fundamentally triadic construction could be alleviated by using conspicuous triangular graphics. Figure 2 shows a way for doing this. In the first place, a triangular graphic such as Figure 2 increases the visual distinction between S-R and S-R-S (or A-B-C) representations for respondent and operant behavior. The apex of the triangle is a dominant position. This highlights the emitted behavior occasioned by a stimulus instead of highlighting the stimulus that produces an elicited response as the S-R diagram does so appropriately.
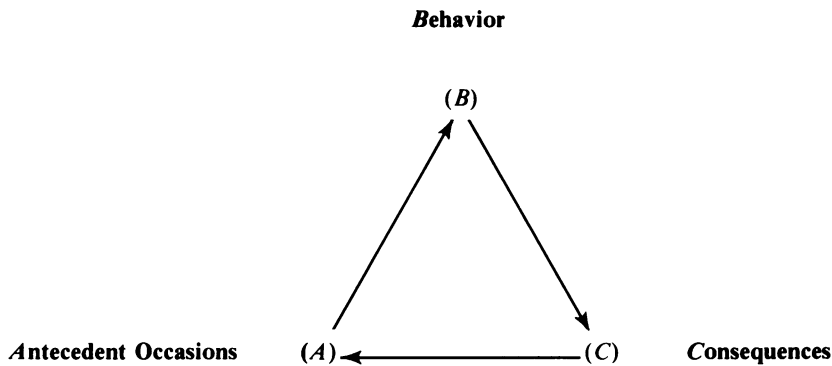
Second, the iterative process of the

Behavior

(B)

Antecedent Occasions   **(A)**◄————————————**(C)**   **Consequences**

Figure 2. A triadic diagram for three-term contingencies.

three-term contingencies can be brought out. The environment that occasions a behavior is changed by the effects produced by that behavior. These effects become part of the environment that occasions the next behavior. This reoccurring cycle also illustrates how operant behavior is a functional class concept comprised of individual instances of behavior over time.

Third, it is an accepted tradition in graphics to allow an enclosed shape—circle, square, or triangle—to represent the inclusion of numerous and large classes of events. Triangles can therefore represent the inclusion of a smaller class of events within a larger class. Thus a person's private events may be represented as a subset of events in a personal history. In turn, the role of the environment in shaping a personal repertoire of behavior may be represented as a subset of the events in the evolution of a culture, and the evolution of a culture may be represented within the evolution of a species by natural selection that provides a heriditary, genetic source of behavior. See Figure 3. While these are widely diverse contexts, Figure 3 helps to suggest the pervasiveness of a three-term analysis and a thoroughly radical behaviorism. A closer relationship between multiple levels of contexts in a particular area of application can also be suggested (see Figure 4). For example, in the natural environment of the classroom, it is useful to distinguish between enduring setting events, temporary setting events, and pin-

pointed events (Meadowcroft & Moxley, 1980). The enduring setting events represent the more permanent and more inclusive collection of events. Ongoing activities can be regarded as a more temporary subset of interrelated events, and pinpointed events may be regarded as a highly specific subset within some temporary activity. Figure 4 suggests the close interrelationships of these narrowing contexts within the naturalistic field of a classroom environment. These distinctions illustrate the variety of sources for control in the classroom as well as the point that controlling consequences are not necessarily limited to those which immediately follow a response.

Fourth, after triangular graphics have been used for comprehensive classes and their relationships, the transition to linear notation can be shown as a straightening out of the 2-dimensional closure to form a 1-dimensional sequence for greater convenience in identifying an extended sequence of pinpointed events. This can help to illustrate the derivation of specific events from more complex contingencies.

At this point, I would like to argue briefly that the differences in the behavior controlled by the different constructions discussed may well be more extensive than the discrimination of a definitional difference between operant and S-R psychology. One difference between dyadic and triadic formulations in general is that while a two-part construction lends itself to an exaggerated, polar separation of elements, a three-part construction

Behaviors

Antecedents   **Consequences**
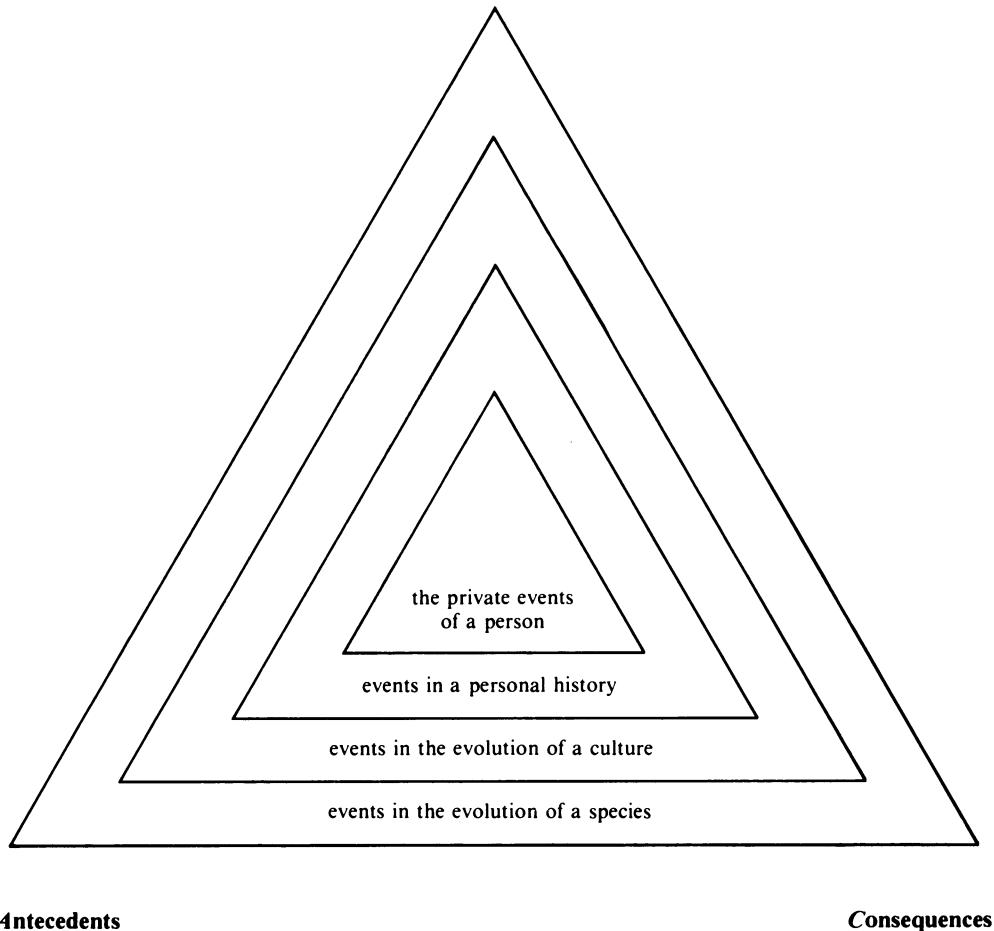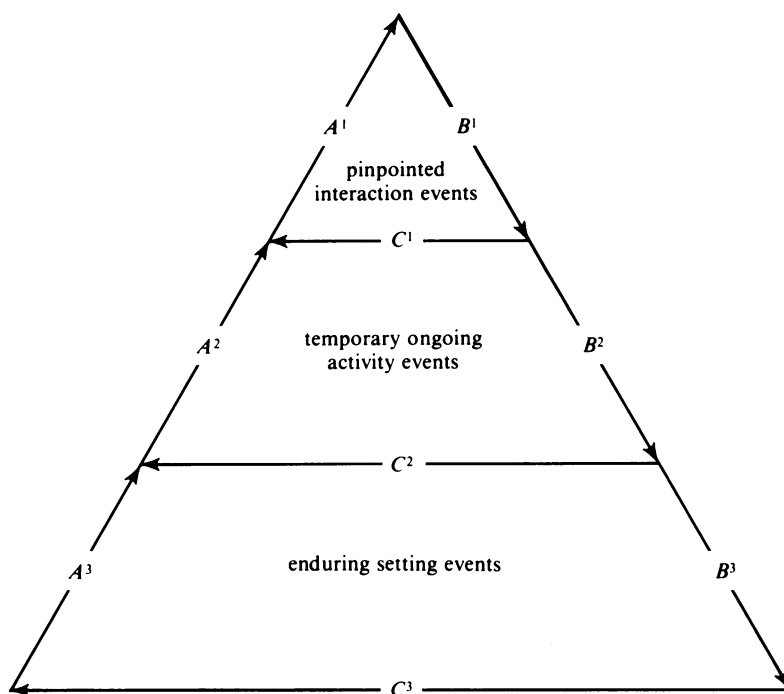
Figure 3. Triadic diagrams for indicating inclusion and relationships between diverse areas under the control of consequences.

lends itself to showing more continuity between the elements and their relationships. This is evident in our language for expressing two-part and three-part constructions. *Either/or, black* and *white, out* and *in, up* and *down, yes* or *no, correct* or *incorrect* express strongly contrasting states that are diametrically opposed to one another and distinctly separate. On the other hand, *beginning, middle, end; past, present, future; tall, taller, tallest* indicate continuity between the states and the passage from one to the other. Two-part dyadic constructions have controlled S-R psychologists and many cognitive investigators whose behavior is rule-governed by linear cause and effect chains, either/or, and right/wrong formulations with seemingly little awareness or understanding of functional consequences. To the extent that these and other readers are under the general control of two-part diagrams of constructed stimuli, they may be unaware

	Antecedents	*Behaviors*	*Consequences*
[1]**pinpointed interaction events**	*Antecedent:* What happens immediately before? Teacher leaves room, asks a question, student reads a book?	*Behavior:* What does the child (or teacher) do? Runs around, recites facts, answers questions, works on project?	*Consequence:* What happens immediately after? Attention, praise, display of work?
[2]**temporary ongoing activity events**	*Supplies & Arrangements:* What is provided to set up the activity? Paint, books, paper & pencil; sitting on floor, seating in circle, movement to another location?	*Student Actions:* What general activity are students engaged in? Free play, reading, sn.all group projects; transition between activities, individual seatwork, peer tutoring?	*Outcomes:* What follows or results from the activity? Another activity, discussion, display of work, recording of progress?
[3]**enduring setting events**	*Resources:* Human, Physical Structure & Resource Materials: Who is there? How is the room laid out? Randomly, in rows of seats, centers? What things are available for use? Manipulatives, books, student products?	*Social Climate:* Is the ongoing interaction noisy, teacher initiated; individualistic, competitive, cooperative?	*Available Feedback:* What feedback is available on student performance? Immediate natural consequences, e.g. painting; tests on accuracy of repetition, rankings and comparisons; recording of extended consequences, collections of work and progress charts?

Figure 4. Relationships between smaller and larger classes of three-term contingencies in the classroom.

of the significance of mediating relationships such as those of functional consequences in a three-term contingency. Thus, when confronted with a discussion of operant psychology or radical behaviorism, they recast it into a two-part formulation (i.e., another variety of S-R formulations) or ignore it.

In addition, the absence of conspicuous graphic diagrams for the three-term contingencies may have contributed not only to confusion among the general public over whether or not Skinner is an S-R psychologist, but it may also have contributed to what may be seen as a kind of fence straddling by Skinner and other behaviorists on the role for temporal contiguity. For example, linear S-R chains are convenient graphics for dyadic concatenations of cause and effect chains. In the classical explications of linear cause and effect chains, temporal gaps in the chain have typically been abhorred. Contiguous connections of some kind are insisted upon. We then find that while Skinner (1956/1972) has criticized "mentalistic" explanations for resorting to constructions for filling these gaps, he also seems to indicate the need for immediate contiguity between a response and its consequence (1971, pp.114-115). And some behaviorists have criticized Skinner for holding on to the contiguity requirements for linear cause and effect analyses without an adequate rationale (Lacey & Rachlin, 1978; Staddon, 1973). This and other appearances taht behaviorists are predominantly guided by linear, two-term analyses may contribute to failures in seeing the significance of a three-term analysis of contingencies.

While a strict linear chain of cause and effect may be an appropriate description as an abstraction in the isolated environments of laboratory experiments, it often seems to be an all too convenient, if often useful, fiction in complex naturalistic settings. It would not be so bad to acknowledge linear chain diagrams as convenient extrapolations as long as there were a more comprehensive diagram which could be referred to as a more complete, if not more precise, source for the extrapolation. Graphics for indicating the fuller, more complex and complete relationships of three-term contingencies should be available for introduction to a general readership and for those who take linear graphics a bit too literally.

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